

## SECTION 23 33 14

### DAMPERS FOR TUNNEL VENTILATION

#### PART 1 – GENERAL

##### 1.01 SECTION INCLUDES

- A. The work of this Contract Specifications Section includes furnishing, installing, and testing of motor operated dampers and appurtenances as shown on the Contract Drawings for Station and tunnel ventilation.

##### 1.02 RELATED SECTIONS

- A. Section 23 09 01, Fan Damper Control Pane;
- B. Section 23 31 14, Ductwork for Tunnel Ventilation
- C. Section 23 34 14, Fan-Motor Units for Tunnel Ventilation
- D. Section 26 05 24, Low Voltage Wires and Cables

##### 1.03 MEASUREMENT AND PAYMENT

- A. General: Separate measurement or payment will not be made for the work required under this Section. All costs in connection with the Work specified herein will be considered to be included or incidental to the Work of this Contract.

##### 1.04 REFERENCES

- A. Where materials or equipment are required to conform to referenced industry standards, the current edition of the most recent revisions as of the date of Request for Proposals shall apply.
- B. Contractor may propose for approval alternate standards to those listed herein, provided that the standards are submitted in the English language, with a point-by-point comparison between the specified and alternate standards included in the submittal. The requirements of proposed alternate standards shall be at least as stringent as the specified standards.
- C. Reference Standards:
  - 1. American Iron and Steel Institute (AISI)
  - 2. American National Standards Institute C1 (ANSI)
  - 3. Air Moving and Control Association (AMCA):
    - a. 500D, Laboratory Method of Testing Dampers for Rating
    - b. 500L, Laboratory Method of Testing Louvers for Rating

- c. 510, Methods of Testing Heavy Duty Dampers for Rating
  - d. 511, Certified Rating Program – Product Rating Manual for Air Control Devices
- 4. American Society for Quality (ASQ):
  - a. C1, General Requirements for a Quality Program.
- 5. American Society of Mechanical Engineers (ASME)
  - a. B18.21.1, Lock Washers (Inch Series)
- 6. American Society for Testing and Materials International (ASTM):
  - a. A36/36M, Specification for Carbon Structural Steel
  - b. A193, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature and High Pressure Service and Other Special Purpose Applications
  - c. A194, Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
  - d. A240, Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
  - e. A276, Stainless Steel Bars and Shapes
  - f. A588, Specification for High Strength Low Alloy Structural Steel with 50 A588 Mksi (345 MPa) Minimum Field Point to 4 inches (100 mm) Thick
  - g. A666, Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bar
  - h. E84 Test Method for Surface Burning Characteristics of Building Materials
- 7. American Welding Society (AWS):
  - a. D1.1, Structural Welding Code - Steel.
  - b. D1.3, Structural Welding Code - Sheet Steel.
- 8. Institute of Electrical and Electronics Engineers (IEEE)
  - a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators
- 9. National Electrical Manufacturer's Association (NEMA):
  - a. ICS-2, Industrial Control and Systems Controllers, Contactors, and Overload Relays, not rated more than 2000 volts AC or 750 volts DC.
  - b. ICS-6, Industrial Controls and Systems Enclosures
  - c. MG-1, Motors and Generators.
- 10. National Fire Protection Association (NFPA)

- a. 70, National Electric Code (NEC)
- b. 130, Standard for Fixed Guideway Transit and Passenger Rail Systems
- c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

11. Underwriters Laboratories (UL):

- a. 508, Industrial Control Equipment
- b. 555, Smoke Dampers
- c. 723, Test for Surface Burning Characteristics of Building Materials.
- d. 2196, Fire Resistive Cable

**1.05 SUBMITTALS**

- A. Provide submittals in accordance with Contract Specifications Section 01 33 00, Submittal Procedures, Contract Specifications Section 01 33 23, Shop Drawings, Product Data, and Samples, Contract Specifications Section 01 42 19, Reference Standards, and the requirements of Article 1.05 herein. In case of any conflict, the more stringent requirements will take precedence.
- B. Within 90 Days after Notice to Proceed, Contractor shall submit names and qualifications of manufacturer of tunnel ventilation dampers for approval; qualification statement shall include but need not be limited to the following data:
  - 1. Theoretical performance curves for dampers proposed to be furnished under this Contract. Performance curves shall be plotted to such scales as will make it possible to read the data accurately.
    - a. The damper performance characteristic curves shall be as follows:
      - 1) Curve plotted with ordinate as pressure drop in inches of water versus face velocity in feet per minute.
      - 2) Curve plotted with ordinate as duct pressure in inches of water versus leakage in cubic feet per minute (cfm) per square foot of damper.
    - b. The following information shall be indicated in each performance curve:
      - 1) Contract title.
      - 2) Name and address of damper manufacturer.
      - 3) Name and address of damper operator manufacturer.
      - 4) Contractor's name and address.
      - 5) Air density.
      - 6) Damper face area.
      - 7) Damper assembly net free area.
      - 8) Damper operator model number.

- 9) Electrical and mechanical characteristics of damper operator (voltage/phase/frequency).
  - 10) Electrical characteristics of damper operator space heater, including voltage and kilowatt input.
  2. Damper manufacturer, damper operator manufacturer and Contractor quality assurance programs shall be in accordance with ANSI C1, AMCA 511 and UL 555S.
  3. A complete list of projects on which similar dampers for rail projects or other industrial applications with high temperature requirements in the US have been installed or furnished. List shall include:
    - a. Name of authority or user (include the Owner's installations, if any).
    - b. Contract number(s).
    - c. Original installation date(s).
    - d. Number and size of dampers and number of operators.
    - e. Current condition of equipment, including estimate of remaining useful life.
    - f. A list of all known failures including, their apparent causes, corrective work affected, and a description of equipment service and operating conditions.
  4. Manufacturer's certificate of compliance and the results of previous Elevated Temperature Test if conducted for certification of such requirements.
  5. List of components proposed to be purchased from other manufacturers (including but not limited to: frame, housing, blades, linkages, bearings, and seals), giving name of manufacturer, type and characteristic of each item.
- C. The Contractor shall submit the following for each type of damper to be furnished under this Contract:
1. Certified Shop Drawings including Bill of Materials for dampers and damper operators, installation drawings including damper power and control wiring, interfacing junction boxes and conduits, installation instructions, dimensioned drawings for installation of structural steel members, mounting and anchorage data, and any additional data required to demonstrate compliance with Contract Documents. Weight of damper modules and operators shall be indicated.
  2. Catalog cuts for damper operators and limit switches.
  3. For each damper size and type provide calculations for the damper torque requirements and the actual operator torque.
  4. Gasket data documenting high temperature capability.
  5. A detailed analysis to demonstrate that the various damper components at their point of critical stress do not exceed the stress endurance limit of the material. Calculated maximum expected stresses for both the normal design pressure

condition and the test condition, together with design properties of the material used to fabricate the damper blades and shafts, shall be submitted for approval.

6. Certificate of Compliance signifying that equipment to be furnished under the Contract meets the requirements specified herein.
  7. Test program plan and schedule.
  8. Factory test procedures.
  9. Field test procedures.
- D. Within 14 Days after successful completion of all factory tests specified herein and of any additional tests conducted at Contractor's own option, Contractor shall submit the following:
1. Certified results for all tests conducted. Actual performance curves verifying the theoretical performance curves previously submitted shall be furnished as part of the damper unit test results. Curves shall include the data specified in Article 1.05A herein. All test data shall be bound in one report. The test report shall be indexed and cross-referenced in an easily understood manner.
  2. All records and results of non-destructive examinations made at completion of each examination.
- E. Operation and Maintenance Manuals
1. At least 30 Days before shipment of the first damper unit, Contractor shall submit for approval three copies of the preliminary maintenance manual that shall provide technical support for damper maintenance. After approval of the preliminary submittal and having made all necessary corrections and amendments required, Contractor shall provide twenty additional copies of the approved dated Operation and Maintenance (O&M) Manuals. One master camera-ready set shall be included as one of the twenty copies to permit additional copies to be made. The master camera-ready copy shall be clearly marked as such on the outside. An electronic copy of the O&M Manual text, drawing and catalog cut files shall also be provided. The O&M Manual shall provide a clear explanation of the theory, operation, and maintenance of the equipment accompanied by photos and schematic, wiring, and mechanical assembly diagrams, as required. The O&M Manual shall be indexed and cross-referenced in an easily understood manner. The O&M Manual shall be loose-leaf bound and shall include, but not necessarily be limited to, the following information:
    - a. Operating instructions.
    - b. Troubleshooting and fault isolation procedures for on-site level repair.
    - c. Procedures for separately removing and replacing damper motor operator, limit switches and individual damper sections.

- d. Damper, damper operator and limit switch disassembly and re-assembly instructions.
  - e. A list of the components that are replaceable at the three possible levels of maintenance: on-site, District Representative facilities, and manufacturer's facility.
  - f. A test procedure to verify the adequacy of repair work.
  - g. A preventive maintenance schedule and instructions detailing lubrication of moving parts.
  - h. A list of technical support items and special tools provided by Contractor.
  - i. A list of tools and test equipment required to perform all maintenance tasks.
  - j. The latest service bulletins with dates which describe service procedures.
  - k. Contractor shall supply twenty copies of all revisions to service bulletins that are included in the maintenance manuals described herein for a period of five years from date of facility opening for revenue service.
- F. Technical Support Items: At least 30 Days before shipment, Contractor shall submit the following:
- 1. Ten sets of special tools shall be provided in total. Special tools shall be those tools that are required to specifically service or repair the damper unit that is being supplied and that are not normally carried in a general machinist's toolbox.
  - 2. Tabulation of spare parts necessary to maintain the dampers procured under this Contract. This table will become a working document to be used by the District's Representatives in the procurement of support items, and shall be updated as changes occur. The spare part items shall be grouped by equipment and components. This list for each item shall give complete ordering and procurement information for that item, including quantity required to maintain inventory for 500 hours' operation. Each item listed shall contain at least the following information: item name, description rating, estimated operating life, current price, manufacturer's name, part name, and drawing reference number. Items that are common to more than one damper shall be cross-referenced. A column, immediately after the columns indicating recommended spare quantities, shall indicate expected delivery time in excess of 60 Days.
- G. Prior to Substantial Completion the Contractor shall submit training materials in accordance with Contract Specifications Section 01 79 00, Demonstration and Training.
- H. Prior to Substantial Completion the Contractor shall submit a recommended spare parts list in accordance with Contract Specifications Section 01 78 44, Spare Parts and Maintenance Manuals.
- I. Record Drawings: Submit record drawings in accordance with Contract Specifications Section 01 78 39, Contract Record Documents.

- J. Prior to Substantial Completion the Contractor shall submit information on the warranty (see Supplementary Conditions Article SC4.7, Guaranty of Work).

## **1.06 QUALITY CONTROL**

- A. Welding: All Components in this Contract requiring welding shall be welded as follows:
  - 1. Code Requirement: Welding shall conform to the requirements of AWS D1.1 and AWS D1.3.
  - 2. Welder Qualification: Welders welding on the work of this Contract shall be qualified in accordance with the requirements of AWS D1.1, Section 5, Qualification.
- B. Source Quality Control
  - 1. Dampers shall be the product of a single manufacturer whose name shall appear on the theoretical performance curves and other data submitted.

## **1.07 STORAGE AND PROTECTION**

- A. Storage: Store all materials and equipment in dry, ventilated, weather tight enclosures.
- B. Protecting Machined Surfaces: Apply a rust preventive on machined surfaces such as flanges and shafts. Use material of a type that is easily removable with solvent during equipment installation.
- C. Protecting Openings: Close pipe connections, ends, and other openings with easily removable plugs, stoppers, or flange covers.

## **1.08 CONTRACT/JOBSITE CONDITIONS**

- A. Design Temperature Conditions: Motor operated dampers shall be designed so that the dampers will be fully operational after exposure to an airstream temperature of not less than 482 degrees Fahrenheit for not less than one hour and an airstream temperature not less than 392 degrees Fahrenheit for not less than two hours (including the one hour at 482 degrees Fahrenheit). Dampers and components shall be capable of withstanding the stresses caused by pressure transient pressures from train piston action, and by reversal of airflow and thermal shock caused by temperature changes of from 0 to plus 482 degrees Fahrenheit.
- B. Design Pressure Conditions: Dampers and components shall be capable of withstanding the stresses caused by transient pressures from train piston action, and by reversal of airflow. The motor operators shall be capable of actuating the dampers against a differential pressure cycling between plus and minus 14 inches water gauge, or fan shut-off pressure (resulting from possible operation of the ventilation fan against a closed damper), whichever is higher, across the dampers. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.

## 1.09 SPARE PARTS

- A. Supply the District Representative with four spare damper operators for each size and type of damper operator, identical to the operators installed to operate the dampers. The damper operator motors shall be complete and labeled with the motor characteristics.
- B. Supply the District Representative with four spare limit switches of each type identical to those installed.
- C. Provide the District Representative with spare damper support bearings. Quantity of damper support bearings shall be 5 percent of each type used on dampers. Store bearings in secure storage containers with permanent labels identifying number, type, manufacturer, bearing location on dampers, and the District Contract Number.

## PART 2 – PRODUCTS

### 2.01 MOTOR OPERATED DAMPERS

- A. General Requirements
  - 1. Dampers shall conform to all the regulatory requirements of NFPA 70 and NFPA 130 where applicable.
  - 2. Dampers shall be furnished complete with damper mounting frames for each damper section and all components, including operators and limit switches, and; with all structural support elements and hardware required for installation of the damper section into composite damper units in their intended positions, and with any additional accessories which may be needed in order to meet the performance requirements as provided in these Contract Specifications.
  - 3. All like components shall be furnished by a single Supplier.
  - 4. Temporary supports and bracing shall be provided to maintain damper square and rigid at all times during handling and erection.
  - 5. Each damper section module shall have integral channel frames with interconnecting linkage between modules and operators that shall permit all blades in damper section to operate in unison. Modules shall be individually removable from composite assembly. All damper modules shall be surface-mounted against the face of structural steel members (beams, support frames, mullions) or ductwork. Furnish all internal intermediate supports and mullions required for installation of the damper sections into composite damper units.
  - 6. Dampers and damper companion flanges may be fabricated in multiple sections where required. The sections shall be interconnected with bolted splice plates. The damper modules shall be of such size that can be brought into the fan rooms and vent shafts through the access provided and to facilitate handling, erection and disassembly, but not greater than 56 inches in blade length. Before



fabrication, the openings for ventilation dampers and the equipment access shall be field verified.

7. Linkages and bearings of all damper modules shall be arranged in such a manner that they are easily accessible upon removal of gasketed cover plates, without removal of entire damper section.

#### B. Damper Requirements

1. All motor operated dampers furnished shall be suitable for installation in either a vertical plane or a horizontal plane, as required. Dampers and damper companion flanges shall be as indicated on Contract Drawings and as specified herein.
2. The dampers shall be designed to be assembled and disassembled in the field with special tools as described in Article 1.05E.1 herein from modular panels. Each damper panel shall be of the multiple parallel blade type, with an independent channel frame; and shall be factory-assembled complete with frames, blades, shafts, bearings, seals, linkage, and all accessories required to erect the modular panels into sections and then into composite damper units. Dampers shall be furnished complete with all intermediate support members and hardware required to complete the installation.
3. Multiple modular panel dampers may be operated by use of jack shafting.
4. Dampers shall be special tools arranged for electric motor operation to two blade positions: fully open and fully-closed. Each damper shall be furnished complete with electric motor operators sufficient in number and capacity to actuate all modular panels in a damper section in unison under the operating conditions specified herein. Thermal overload protective devices shall be capable of being overridden during emergency operations. Dampers shall be suitable for continuous operation in either open or closed position.
5. Motor operated dampers shall have a net free face area of not less than 80 percent measured to the inside of the damper frame clear opening when blades are fully open.
6. Upon loss of power, dampers shall have a fail position as shown on the Contract Drawing.
7. Each damper section shall be provided with two blade-position sensing DPDT (double pole, double throw) limit switches for remote indication of the damper position, one for fully open position and one for fully closed position. Switches shall be provided with independent contacts mounted to positively detect full-open and full-closed positions. Limit switches for dampers required to operate in high temperature shall be suitable for operating at Design Temperature Conditions.
8. For multiple section dampers, and dampers that operate in a group, limit switches shall be wired as shown on the Contract Drawings to provide a common open or closed indication for each damper section, or damper group.

9. All power and signal wiring for damper operators and limit switches shall be wired to barrier strips in common weatherproof cast iron terminal box fitted for conduit entry, drilled and tapped for 1-1/2 inch conduit, and mounted on the damper mullion or other suitable position. Control cables shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. If necessary, the terminal box and wiring may be removed for shipment, but the damper manufacturer shall provide adequate instruction for installation and electrical connection in the field. Damper manufacturer shall designate routing and attachment points for all damper-mounted electrical items.
10. In order to meet the requirements of NFPA 130 that covers the tunnel area, all field cables running from the motors junction box and through ducts/plenum up to the Junction Box placed outside the tunnel section shall conform to the requirements of NFPA 130 and as described in Contract Specifications 26 05 24, Low Voltage Wires and Cables.

C. Damper Performance

1. Performance requirements listed below are based on the air density shown on the Contract Drawings.
2. Contractor shall ensure that the damper manufacturer certifies that the dampers comply with UL 555S, Class 1 requirements and that, when the dampers are fully closed and holding against a maximum differential pressure of plus or minus 14 inches water gauge, or fan shut off pressure (resulting from possible operation of the Station ventilation fan against a closed damper), whichever is higher, leakage through the damper assembly will not exceed 16 cfm per square foot of damper. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.
3. With the dampers in the fully open position, and air flowing across the damper at a uniform velocity of 2,000 fpm, the pressure drop across the dampers shall not exceed 0.15 inch water gauge.
4. The dampers and their associated structural supporting systems shall, when the dampers are in the fully closed position, be capable of withstanding a maximum differential pressure across the dampers of 14 inches water gauge for a minimum of 4,000,000 pressure reversal cycles. Contractor shall ensure that the damper manufacturer submits an analysis confirming this capability.
5. Damper and operator shall be capable of being fully cycled (open to close to open, or vice versa) for a minimum of 100,000 cycles before failure occurs. Contractor shall ensure that the damper manufacturer submits a certificate along with test data for the damper model supplied demonstrating this performance. Individual cycle times shall not exceed the duty cycle of the damper operator.

## 2.02 DAMPER FABRICATION AND COMPONENTS

- A. Damper blades shall have an airfoil cross-section and shall be fabricated of Type 316 stainless steel, in accordance with the requirements of ASTM A 240 and A 666.

The width of the blades measured in the direction of airflow shall not be less than 6 inches and shall not be greater than 12 inches. Damper blades in the open position shall not extend beyond the damper frame. Damper blades shall have metal-to-metal overlap in the closed position. Blade edge sealing strips, regardless of their composition, will not be permitted as a substitute for a true blade-to-blade overlap.

- B. Damper blade shafts and jackshafts shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 276 and A 666. Blade shafts shall be stub axles or full-length construction and shall be not less than 3/4 inch in diameter or square. Jackshafts shall be not less than 1 inch in diameter. The design of the damper blade shafts shall incorporate the devices required for locking the blades onto the shafts. Damper blade shaft axis shall always be horizontal.
- C. Damper blade deflection, with blade supported by shaft, shall not exceed L/360 of the span length between centers of shaft bearings with damper in closed position while withstanding the maximum combined Design Temperature Conditions and Design Pressure Conditions listed in Article 1.07 herein, and shall not exceed L/180 of the span length between centers of shaft bearings with damper in closed position while withstanding the maximum combined fan shut-off differential pressure (resulting from possible operation of the Station ventilation fan against a closed damper), if it exceeds 14 inches water gauge, and maximum temperature of not less than 482 degrees Fahrenheit. Coordinate with fan manufacturer to establish maximum fan shut-off pressure.
- D. The damper blade and shaft assemblies shall be supported at each end by means of carbon-graphite sleeve type bearings, suitable for operating at Design Temperature Conditions. Bearing mounting shall be external to frame.
- E. Damper linkage shall be external heavy-duty industrial type, not less than 1/4-inch by 3/4 inch flat bars fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 276 and A 666,. Linkage shall interconnect damper blade shaft crank arms that shall be fabricated of Type 316 stainless steel not less than 3/16 inch thick. The linkage bearings shall be fabricated of reinforced thermoplane or other material suitable for the specified operating conditions, as approved by the District Representative. The linkage brackets shall be side-mounted and mechanically interconnected with the shafts. Blade shaft crank arms to be welded to axles. Linkage shall be capable of transmitting a minimum of 150 percent of operator load. All linkage parts and assemblies shall be accessible for maintenance and repair after final assembly. A turnbuckle linkage adjustment shall be provided with each linkage to provide a convenient means of adjusting the length of the connecting rod and thereby the damper closure. Linkage elements shall be sized so that the maximum deflection of any element when subjected to the Design Temperature and Pressure conditions specified in Article 1.07 herein shall not exceed L/360, where "L" is the length.
- F. Damper frames shall be a channel cross-section with not less than a 12-inch web and a three-inch flange on the mounting side and two-inch flange on the opposite side and shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 240, A 276 and A 666, with a minimum thickness of 3/16 inch. The corners of the frames shall be welded and reinforced by means of riveted gusset plates.

- G. Motor operated dampers shall be furnished complete with all structural support elements necessary for the installation of the dampers, including the following: all intermediate supports, both horizontal and vertical; all clip angles and other framing members as required at the head, sill, mullion and jambs of each damper assembly; and all screws, bolts, nuts, washers and other hardware required to complete the installation. All intermediate supports and framing members required for assembly and installation of the damper modules shall be fabricated of stainless steel Type 316, in accordance with the requirements of ASTM A 240, A 276 and A 666.
- H. Lifting lugs shall be of the same material as the exterior damper frame not less than 3/8 inch-thick steel and shall be welded on exterior of damper frame in sufficient number to facilitate future on-site installation and removal. Lugs shall be a minimum of four per each knocked down damper component or frame and spaced to prevent deformation of component when suspended from chains during installation.
- I. Mullion supports shall be designed by Contractor. The mullions shall be the full length and width of the dampers. Mullion supports shall be of stainless steel Type 316, fabricated in accordance with the requirements of ASTM A 240, A 276 and A 666, and shall have punched or drilled holes, equally spaced for damper module attachments. Number of damper mullion support holes and space between the holes shall be selected by Contractor.
- J. Damper companion flanges shall have punched or drilled holes equally spaced not more than 12 inches on centers.
- K. Damper Hardware
  - 1. Positive locking devices shall be provided for all nuts and bolts located within the airstream.
  - 2. In accessible areas, fasteners shall be hexagonal head bolts with hexagonal nuts, provided with heavy-duty lock washers.
  - 3. In inaccessible areas, fasteners shall be hexagonal head tap bolts, provided with heavy-duty lock washers.
  - 4. Bolts shall be not less than one half inch in diameter unless otherwise indicated.
  - 5. Bolts shall be stainless steel and shall conform to the requirements of ASTM A 193, Grade B8M or Grade B8MA, equivalent to AISI Type 316, with suitable lock washers conforming to ASME B18.21.1. Lock washers shall be stainless steel, equivalent to American Iron and Steel Institute (AISI) Type 316.
  - 6. Nuts shall be stainless steel and conform to the requirements of ASTM A 194, Grade 2H, equivalent to American Iron and Steel Institute (AISI) Type 316.
  - 7. All other damper hardware, including, but not limited to clevis pins, cotter pins, groove pins, nut retaining wire, and spacers shall be stainless steel Type 316.

- L. Dampers shall be fastened to damper intermediate supports and mullions, by means of stainless steel Type 316 fasteners, type and size as indicated on the Contract Drawings and as specified herein.
- M. Damper operator mounting brackets shall be fabricated of not less than 3/8-inch-thick stainless steel Type 316 and shall be bolted to the mounting surface. Mounting bracket shall be constructed in such a manner that bracket cannot be moved by hand to cause binding or misalignment of bearing(s) and damper shaft(s).
- N. Damper blade stops and jamb seals shall be fabricated from stainless steel Type 316.
- O. Contractor shall provide a one fourth inch-thick silicone base gasket covering the full width of each flange between damper frames and damper companion frames and between damper frames and other associated companion flanges. Gasket material shall be suitable for exposure to Design Temperature Conditions without emitting toxic or noxious fumes. Submit data for approval documenting high temperature capability.
- P. The initial charge of lubricants for damper components shall be supplied by the damper manufacturer.

## **2.03 DAMPER OPERATOR REQUIREMENTS**

- A. The damper operators shall be electrical type only. Electro-hydraulic operators shall not be used. The motor operators shall be capable of actuating the dampers against the Design Pressure Conditions Article 1.08B herein. The operators shall be capable of changing the position of the dampers from fully closed to fully open, or from fully open to fully closed within a period of not more than 10 seconds. The operators shall be selected and their required quantity shall be determined, such that the normal torque output required for each damper or damper section does not exceed two thirds of the rated operator capacity. This selection criterion provides that each operator has at least 50 percent excess capacity. However, in no case shall there be less than two motor operators provided per damper installation. Motor operators shall be able to operate continuously open or closed under the specified Design Temperature Conditions and Pressure Conditions listed in Article 1.08 herein. Dampers shall be able to cycle (open and close) continuously for one hour under the specified conditions. Linkage from the damper operator shall be fabricated of stainless steel Type 316 and shall be connected to the interconnecting blade linkage with a stainless steel Type 316 pin, such that full force of operator is applied to the blade connecting linkage.
- B. The motors shall be totally enclosed and wound for one third horsepower maximum, 120-volt, single phase, 60-Hertz alternating current in conformance with NEMA MG-1. The motor windings and motor leads shall be copper and shall be so insulated that the temperature rise of the insulated motor windings shall not exceed 176 degrees Fahrenheit measured by resistance method, above an ambient temperature of 104 degrees Fahrenheit (giving a maximum winding temperature of 280 degrees Fahrenheit).

- C. Thermal protective overload devices shall be provided with a bypass for emergency conditions. The thermal protective overload bypass shall be provided with leads terminated in the conduit box.
- D. Motors shall be equipped with factory-installed resistance space heaters within the motor enclosure in accordance with NEMA IS1.1 to prevent condensation of moisture in the motor windings. The heaters shall be provided with leads terminated in the conduit box. The heaters shall operate on 120 volts, single phase.
- E. Where indicated, upon loss of power to the motor operators, Dampers shall be designed to have a fail position as shown on the Contract Drawings.
- F. Damper operators shall be furnished with auxiliary limit switches that meet the requirements of NEMA ICS-6 at both ends of the motor travel. These limit switches are in addition to the limit switches specified in Article 2.01B.7 herein. Each switch shall have a minimum of two sets of single-pole contacts, one normally open and one normally closed; single-throw contacts will be acceptable, provided that the circuits are electrically separate and fully insulated to permit their use on opposite polarities. The contacts shall have an electrical rating of not less than 5 amperes at 120-volt, 60-Hertz alternating current.
- G. Motor leads and limit switch contacts shall be factory-wired to cast iron weatherproof terminal boxes fitted for conduit entry. Power, control and heater wiring shall be as specified in Contract Specifications Division 26. Control cables shall conform to the requirements of NFPA 130 and as described in Contract Specifications Section 26 05 24, Low Voltage Wires and Cables. Conduit boxes shall have tightly fitting, gasketed covers designed to resist the entrance of dust and fluids; and shall have threaded conduit openings. All electrical components, conduit and boxes shall be weatherproof. Conduit boxes shall be mounted to the motor mounting plates.
- H. Damper motor operators shall be located as shown on the Contract Drawings.

#### **2.04 DAMPER FINISHING**

- A. Damper Finish: Mill.

#### **2.05 NAMEPLATES**

- A. Each damper shall be provided with a stainless steel Type 316 nameplate permanently stamped with the name and address of the manufacturer, Manufacturer's model type, serial number and the District's designated damper number.
- B. Each damper operator shall be provided with stainless steel Type 316 nameplate permanently stamped with the Contract title, name of Contractor, name and address of the manufacturer, the motor horsepower, voltage, phase, frequency, insulation type, full-load current, locked-rotor current indicating code letters, the design temperature rise over ambient of the motor, the terminal connection chart for the motor, rating of the space heater, speed in revolutions per minute, motor type,

service factor, motor serial numbers, bearing numbers and shop order number and the District's designated damper number.

- C. Nameplates shall be attached to respective component in a location conspicuous after installation with stainless steel Type 316 fasteners.

## 2.06 FACTORY DAMPER TESTS

- A. The District may, at his option, witness any or all of the tests specified herein. Contractor shall notify the District Representative, in writing, not less than 4 weeks in advance as to the location and dates of the factory tests.
- B. One test sample damper unit not less than 42 inches by 42 inches shall be subjected to tests. The test shall be conducted in a test facility located either at the manufacturer's plant, or at a suitably equipped testing laboratory. The test facility shall be approved by the District Representative.
- C. Performance Tests: The sample damper shall be tested in accordance with the latest edition of AMCA 500, using a test set-up approved by the District Representative as appropriate for the intended installation of the dampers. Test data shall be recorded on AMCA data submittal forms, or the equivalent thereof as approved by the District Representative. Certified test data, and certified performance curves for all of the coordinates specified in these Contract Specifications shall be submitted to the District Representative for approval. Conduct the following performance tests:
  - 1. Leakage Test: Measure maximum leakage in cfm per square foot of damper with Design Pressure Conditions.
  - 2. Pressure Drop Test: Measure maximum pressure drop across damper in fully open position with a uniform face velocity of 2,000 fpm.
  - 3. Blade Deflection Test: Measure actual deflection of the damper blade at the point of critical stress. This shall not exceed the calculated deflection.
- D. Operational Test: The damper, while remaining in the fully closed position, shall be subject to not less than 30 pressure reversals in one hour under Design Pressure Conditions. Damper shall still be operational with no visible damage or distortion to any components at the end of the test.
- E. If test has not previously been performed to provide data specified in Article 2.01, C.5 herein, conduct test to demonstrate that damper and operator are capable of being fully cycled (open to close to open, or vice versa) for a minimum of 100,000 cycles before failure occurs. Individual cycle times shall not exceed damper duty cycle.
- F. Elevated Temperature Test: One damper module and operator shall be subjected to an elevated temperature of not less than 482 degrees Fahrenheit for 1 hour and a temperature of not less than 392 degrees Fahrenheit for two hours. The damper shall be powered open and closed at the beginning of the test period, and every 10 minutes thereafter for the first hour, while subjected to a temperature of not less than

482 degrees Fahrenheit. At the end of one hour, the damper shall remain subjected to an elevated temperature of not less than 392 degrees Fahrenheit for an additional hour with the damper powered open and closed every 10 minutes during the second hour. At the end of the second hour of the test, the damper shall be powered open and closed for 10 cycles. The damper and operator shall operate without failure throughout the entire high temperature test. This test may be waived if the damper manufacturer can demonstrate to the approval of the District that the identical model damper and identical model operator combination have passed an elevated temperature test on previous projects.

- G. Each damper assembly shall be satisfactorily operated by its damper operators before delivery.

## **PART 3 – EXECUTION**

### **3.01 INSTALLERS**

- A. The District Representative shall be advised in writing of the name and title of the proposed field service engineer, who upon District Representative approval shall have complete authority to represent and to act for Contractor.
- B. The manufacturer's field service engineer shall assist the Contractor with the installation of the dampers.

### **3.02 EXAMINATION**

- A. Surfaces and structures to which the products will be affixed, placed, and installed shall be inspected by Contractor in the presence of the equipment manufacturer before the work begins. Contractor shall apply finishes to surfaces that will be concealed by the installation of products prior to product installation.
- B. Particular attention is called to the fact that nominal dimensions have been indicated on the Contract Drawings for construction of the dampers. However, the actual openings where dampers are to be installed may vary from the indicated dimensions. In providing dampers to close these openings, Contractor shall verify all dimensions in the field and shall design and build each frame to fit the respective opening, without leaving spaces between the frame and structure. All spaces between the frame and the structure shall be filled with grout, neat portland cement or other approved sealing materials, all properly bonded to the existing surface.
- C. Prior to installation, the Contractor shall measure or survey the as-built facilities and prepare a layout and section drawing showing the centerline of installation and top of foundation elevations. The horizontal centerline shall be based on the as-built centerline of the tunnel-side opening frame. Vertical control shall be based on the as-built tunnel-side opening frame such that all pieces line up with the tunnel-side opening. Submittal and approval of this layout and section drawing is required before installation can proceed.



- D. Contractor shall note any items that may infringe on the necessary clearances for the equipment.

### **3.03 PREPARATION**

- A. Ventilation equipment shall be carefully protected at the Jobsite in a manner to preclude the possibility of damage to the equipment.
- B. The permanent anti-condensation motor space heaters for the damper motors shall be energized with temporary power before and after installation until permanent power is available. Contractor shall energize the motor space heaters within 24 hours after the damper is delivered to the Jobsite.
- C. Equipment shall be located so that working space is available for servicing, replacing, lubricating, and gaining access to controls.

### **3.04 ERECTION**

- A. The damper manufacturer's rigging instructions shall be carefully followed.
- B. Dampers shall be supported by damper mating frame as indicated on the Contract Drawings.
- C. The damper-mounting members shall be secured to the structure using one half-inch concrete anchors, unless otherwise indicated on the Contract Drawings.

### **3.05 INSTALLATION**

- A. Dampers shall be installed as indicated on the Contract Drawings. The damper frame shall be bolted to the damper mating frame, with one fourth-inch-thick silicone gasket between, using stainless steel Type 316 fasteners. All fasteners shall be uniformly tightened by means of a torque drive to provide a secure airtight installation.
- B. Apply anti-seizing compound to the threads of stainless steel bolts and studs.
- C. The operators for each damper shall be mounted as specified herein.
- D. All dampers, connecting bars, linkages and operators shall be installed and adjusted so that: when a damper is fully open, the damper blades shall be parallel to airflow to provide minimum pressure loss and obstruction to airflow; when a damper is fully closed, the damper blades shall be perpendicular to the airflow with seals pressing against mating surfaces along their entire length to provide closure to meet leakage requirements.
- E. There shall be no flutter, rattling or vibration of damper, connecting bar and linkage either when the damper is operating or when the damper is in the fully open or fully closed positions. Each damper shall be installed so as to provide smooth operation, opening and closing without shock or slamming.

- F. All damper linkage shall be properly installed and connected to its respective operator to prevent blade flutter and connecting bar and linkage distortion or binding during operation. Undue flexure or bending of connecting bars and linkage shall be cause for rejection. Such connecting bar and/or linkage shall be replaced with the necessary corrected design, higher strength materials, and proper size of components.
- G. After installation and before the start of testing, the equipment shall be lubricated. Equipment shall be checked for clearances and proper alignment.
- H. Perform all non-power alignment, adjusting, and testing as required by the manufacturer's installation procedures.
- I. Before operating any damper for the first time, by means of the damper operator, Contractor shall manually open and close the damper to verify that there is no blockage of blades, seizure of damper or damper operator, or cause damage to any item of equipment, or injury to personnel.

### **3.06 ELECTRICAL AND CONTROL**

- A. All interconnecting power and wiring between ventilation components will be installed, terminated and tested by the Contractor. Contractor shall provide access to equipment and resolve discrepancies in ventilation equipment as required.
- B. Inspect all power and control wire connections and perform all continuity testing to ensure proper installation, and meger testing to ensure insulation integrity is maintained after installation is completed. Perform all functional alignment, adjusting, and testing as required by the equipment manufacturer's instructions.
- C. When the electrical installation work is completed and verified, advise the District's Representative so that field tests can be performed. After field testing is completed, restore all equipment to its proper operating condition.
- D. All power and control wiring external to the ventilation equipment shall be provided by the Contractor.

### **3.07 FIELD QUALITY CONTROL**

- A. Equipment shall be installed in accordance with the approved Shop Drawings and the equipment manufacturers' installation instructions and recommendations.
- B. All installation procedures shall conform to the equipment manufacturer's instructions. Checklists shall be used and signed off by the responsible installer as well as by the equipment manufacturer's representative.
- C. Contractor shall provide the manufacturer's field service engineering and inspection reports to District Representative to confirm that the dampers are properly installed and tested.

- D. Field service shall be performed periodically as required during the construction and testing of the District Representative construction contracts. Field service shall not be less than 50 Days.
- E. The duties, responsibilities, and qualifications of the field service engineer shall be:
  - 1. Responsible for advising the installation contractors on the proper procedures for the installation of the fan equipment.
  - 2. To have a thorough knowledge of the dampers and the associated systems.
  - 3. To have a thorough knowledge of the test results and performance requirements of all material and equipment supplied.
  - 4. To prepare and submit to the District Representative a written report on the activities and findings for each visit made within 15 Working Days of the visit.

### **3.08 FIELD TEST**

- A. Upon completion of the installation of all ventilation equipment and the installation and verification of the power and local control wiring, Contractor shall notify the District Representative in writing at least four weeks before the field testing to have the District Representative present to witness the tests. Contractor shall also notify the field service engineer for assistance in the performance of the tests. Contractor shall be responsible for performing testing of dampers in the field and shall submit field test procedures.
- B. Field tests shall be performed under the technical guidance and supervision of the manufacturer's field service engineer. The field service engineer shall provide the field test instrumentation and perform the tests.
- C. Electricians to energize the ventilation equipment and make temporary connections where required and assist the field service engineer shall be provided by the Contractor.
- D. Visual and operating field test procedures are as follows:
  - 1. Each damper shall be subject to rotation reversal tests. A cycle of rotation reversal is defined as reversal from fully open to fully closed position, and then back to fully open position. Each damper shall require ten cycles of rotation reversal.
  - 2. After completion of reversal tests for tunnel ventilation dampers, each damper operator shall be de-energized and checked to confirm that it will fail in the position as indicated on the Contract Drawings.
- E. After completion of all field tests and after the final visit by the field service engineer, Contractor shall submit a field test and inspection report. Field test report shall include copies of raw data, measured results, calculations, and all data derived from tests to confirm compliance with specified performance.

**3.09 ADJUSTING:**

- A. Check operation of internal damper motor operator limit switches to ensure that undue stress is not placed on the damper motor operator when the damper is either fully opened or fully closed.

**END OF SECTION 23 33 14**